Acoustic Guitar Pickup: The Challenge of Realizing Great Sound Tone

One of the greatest inventions of the acoustic guitar music would be a pickup. An acoustic guitar has a built in amplifier, in which its hollow body acts as a sound chamber, enlarging sound the sound wave. However, these naturally produced amplification challenges musicians to produce greater volume and allow them to move during the performance. The endeavor to overcome the handicap of acoustic guitar music led to the invention of the pickup. A little piece of science creating the great sound of music!

"Challenge towards the best guitar sound"

Technology has enriched human life in most of the fields. Especially the invention of the pickup, which converts sound to an electronic signal, was one of the greatest attributions in the music field. As a result of an acoustic guitar creating an echo in the hollow cavity (as shown in Figure 1) when a set of strings are stretched, the acoustic guitarist had trouble performing in a huge hall without any sound amplifying equipment such as a microphone. Many guitar players used the microphone to amplify the sound of the guitar, but the microphone limited movements on stage while performing. The microphone was adequate enough to amplify the echoes from an acoustic guitar's body when a guitarist played on a fixed position. However, some acoustic guitarists desired to move around on stage during the performance. As shown in Figure 2, some guitar players started fixing the microphone in or out of the guitar body because some guitar players wanted to let the audience hear only the guitar sound. They did not prefer the use of a microphone because it would contain some noise from the air.

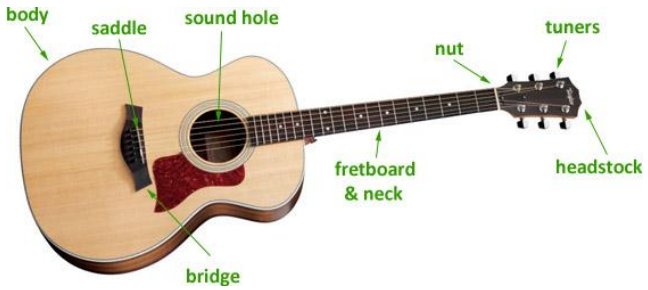

Figure 1. Parts of Acoustic Guitar [1]

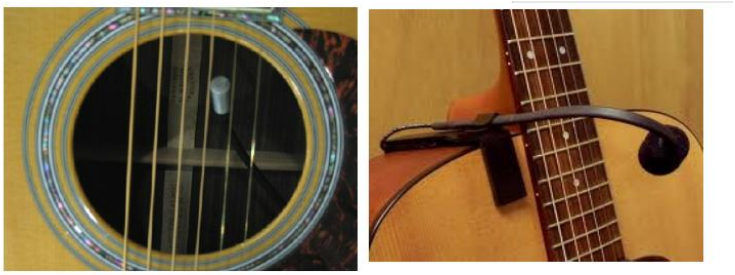

Figure 2. The fixed microphone inside of the body (a) and outside of the body (b) [2]

Electromagnetic pickup: similarly applied to the electronic guitar

Lloyd Loar, an employee at the Gibson Guitar company, invented the electromagnetic pickup in the 1920's [3]. After the magnetic pickup was developed, the electronic guitar became popular, in which gave rise to the brand of music called rock. The invention of the magnetic pickup also accelerated the increasing popularity of the acoustic guitar. The electromagnetic pickup helped not only guitar players to produce louder sounds, but also to cover the weaknesses of the microphone which contained noise in the air. The electromagnetic pickup converted vibration from only the strings into an electronic signal. The principle that made pickups work was Faraday's law of electromagnetic induction [4]. As shown in Figure 3, the

pickup consists of a coil of wire wound up around a magnet. The guitar string is made out of iron, steel, or a combination of both. When the steel string, which is in the magnetic flux, is plucked, the vibration of the string changes the magnetic flux. Then the electric current is created in the wire at the same frequency as how much the string vibrates, and the generated signal is fed to the amp [5]. The electromagnetic pickup is used in both electric guitars and the acoustic guitars. The guitarist's plucking hand is placed on the sound hole because the greatest amount of frequency that the strings produce is located at the top of the sound hole. Therefore, electromagnetic pickup is located on the sound hole right below the strings as shown in Figure 4. This is the reason why the electromagnetic pickup is also called a sound hole pickup if used with the acoustic guitar.

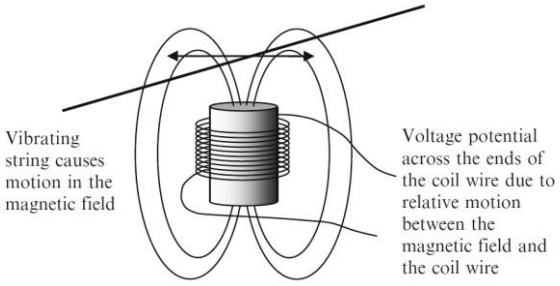

Figure 3. Vibrating Wire Inducing a Voltage [5]

Figure 4. An electromagnetic pickup [6]

Piezoelectric: solution for non-metal string

Electromagnetic pickup works for steel string guitar, but nylon string guitar (called Classic guitar) cannot utilize the electromagnetic pickup. During the 1960s, pickup manufacturers realized that if a small piezoelectric crystal could be attached to the acoustic guitar, the vibrations from the guitar would produce pressure upon the crystal and create a series of corresponding electric pulses [7]. This generation of charges is called the piezoelectric effect which was first discovered in 1880 by Pierre Curie and Jacques Curie, two French physicists and brothers [8]. The Curie brothers discovered that piezoelectric materials, which is called a *piezo*, can produce electricity [8].The origin of the word "*piezo*" is Greek, and it means "I am pressing" [8]. Normally, the charges in a piezoelectric material are perfectly balanced. After an external force is applied to the piezoelectric material as shown in Figure 5(b), net positive and negative charges appear on the opposite sides as shown in Figure 5(c). As a result, the piezoelectric material generates voltage. If the amount of force on the piezoelectric material is as much as how much the acoustic guitar is vibrated, it generates voltage. Based on that principle, this specific kind of pickup is called the piezoelectric pickup. Depending on where the piezoelectric material is located, the under-saddle pickup and the soundboard transducers are separated as discussed in the next section.

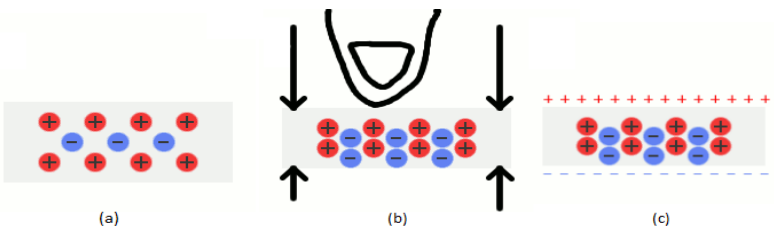

Figure 5. Process of generating voltage in piezoelectric material

Piezoelectric pickup: Under-saddle Pickups

An Under-saddle pickup has the piezoelectric material under the saddle as shown in Figure 6(a). Piezoelectric material is pressed through the saddle when the guitar player plucks the string as shown in Figure 6(b). However, the piezoelectric material under the saddle does not generate enough voltage to make a louder sound because of the thin piezoelectric material. The transducer the mechanic energy to electronic energy, and an amp amplifies the electronic signal. As a result, most of the acoustic guitars with the under-saddle pickup have a preamp on the board as shown in Figure 7. Since the preamp needs more voltage to amplify the electronic signal, it uses a battery. These two parts, the piezoelectric material under the saddle and the preamp, comprise the under-saddle pickup.

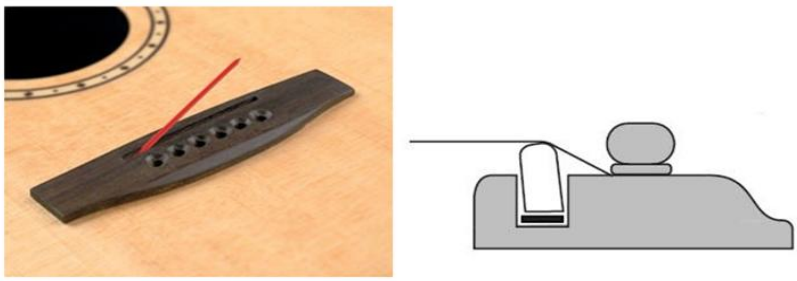

Figure 6. Piezoelectric material under the saddle [9]

Figure 7. Installed preamp and battery for acoustic guitar

Piezoelectric pickup: Soundboard Transducers

The other piezoelectric pickup is the soundboard transducer. As shown in Figure 8, the soundboard transducer can be located anywhere inside or outside of the upper body. Since the soundboard transducer is not limited to where it should be located as long as it is attached to the upper body, it can be utilized in other string instruments such as the violin. Given the difference in its location within the upper body portion of the acoustic guitar, the produced sounds are a little bit different. The guitarists will set up the soundboard transducer in order to attain the kind of sound they want to produce. Generally, most guitar players set it up around the bridge to maximize the piezoelectric effect. Since most of the soundboard transducers do not have a preamp, which the under-saddle pickup does possess, they may need an external amp (as shown in Figure 9) in order to amplify the acceptable electronic signals.

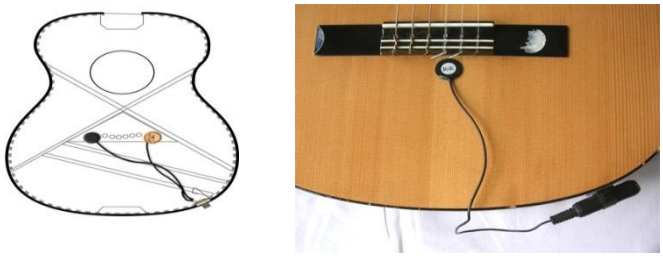

Figure 8. Soundboard transducer on the upper body [10]

Figure 9. External preamp

Dual-source pickup: finding the best combination.

Many acoustic guitar players were not satisfied with using only a pickup, so they tried using the microphone together. Trouble came when they had to give up showmanship due to the conflict of the immovability with the microphone stand. Many pickup manufacturers started combining a microphone with a pickup such as the electromagnetic pickup with the microphone as shown in Figure 10, the under-saddle pickup with the microphone as shown in Figure 11, the soundboard transducer with the microphone as shown in Figure 12, and the under-saddle pickup with the soundboard transducer. They also have blended multiple sources of pickups together such as the under-saddle pickup and soundboard transducer.

Figure 10. Blended Pickup (combination of magnetic pickup and the microphone)[11]

Figure 11. Blended Pickup (combination of under-saddle pickup and the microphone)

Figure 12.Blended Pickup (combination of soundboard transducer and the microphone)[12]

Conclusion

Many acoustic guitar players want to the audience to be able to listen to the most beautifully played melody. These desires for producing better guitar sounds during their performances lead to the pickup manufacturers accelerating their development for the acoustic guitar pickups. Even though an acoustic guitar pickup transduces the vibration of the string to electronic signals, the electronic signal might not be enough to amplify the sound for a huge concert hall. Therefore, guitar players use the preamp to support amplifying the volume of the guitar. Through the preamp, they are also able to make the artificial sound of the acoustic guitar because the preamp is able to adjust the electronic signal. However, a pickup (or combination with the microphone) which is able to capture the natural sound of the guitar perfectly does not yet exist. But, it is safe to say that it will not be long until the natural sound of the acoustic guitar can be heard through an amplifying device.

References

[1] B. McQueen, The Parts of the Guitar [Online] Available: http://www.guitarfriendly.net/the-parts-of-the-guitar/

[2] Anonymous, Meridian Guitar external [Online] Available: Microphonehttp://www.wonderwood.de/shop/fr/73-kk-sound-meridian-externes-mikrofon.html

[3] Anonymous "Technology Review," *For those about to rock, we salute you*. Cambridge: June 2002. Vol. 105, Iss. 5; pg. 104

[4] An Introduction to the Use of Electromagnetics in Musical Instruments: Basic Analytical and Practical Approaches

[5] R. M. French(2012) Technology of the Guitar(1se ed.)[Online] Available: http://zb5lh7ed7a.search.serialssolutions.com/?ctx_ver=Z39.88-2004&ctx_enc=info%3Aofi%2Fenc%3AUTF-8&rfr_id=info:sid/summon.serialssolutions.com&rft_val_fmt=info:ofi/fmt:kev:mtx:book&rft.genre=book&rft.title=Technology+of+the+Guitar&rft.au=French%2C+Richard+Mark&rft.date=2012-05-16&rft.pub=Springer+US&rft.isbn=9781461419204&rft.externalDBID=n%2Fa&rft.externalDocID=972063&paramdict=en-US

[6] Anonymous , Sunrise Vs L.R. Baggs M1 pickups [Online] Available: http://frozeninanimation.wordpress.com/2012/01/03/sunrise-vs-l-r-baggs-m1-pickups/

[7] Chaz, (2009 March 22) How do Piezo-electric – acoustic guitar pickups work? Gear Vault[Online] Available: http://gear-vault.com/how-do-piezo-acoustic-work/

[8] W. K. Schomburg.(2012). *Introduction for microsystem design*.1. pp 137-157. Available: http://link.springer.com/chapter/10.1007%2F978-3-642-19489-4_12

[9] Anonymous, B-BAND PICKUPS & SYSTEMS [Online] Available: http://www.acousticon.com/B_Band.htm

[10] Aribai, PIEZO PICKUP HUM [Online] Available: http://www.guitarampmodeling.com/viewtopic.php?f=18&t=2364

[11] Fishman Inc. [Online] Available: http://www.fishman.com/products/view/rare-earth-blend

[12]K&K sound Inc.[Online] Available: http://www.kksound.com/products/trinity.php#simple5